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Economic Analysis of Biodiesel Produced from Waste Cooking Oil

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ABSTRACT

Present work is focused on comparing the economic feasibility of biodiesel with petroleum diesel. It includes estimates of various resources used in the production of biodiesel from waste cooking oil starting from waste cooking oil to various reactants, energy and labor cost. Estimates are prepared using some existing data and other suitable assumptions. The estimated biodiesel conversion cost comes about 11 rupees per kg whereas waste cooking oil biodiesel cost comes at 35 rupees per kg. Thus WCO proves to be a greener and economically viable feedstock for biodiesel production.

KEYWORDS: Economic feasibility, Biodiesel production, waste cooking oil.

INTRODUCTION

The world is presently confronted with the twin crises of fossil fuel depletion and environment degradation. Indiscrimination extraction and lavish consumption of fossil fuels have led to reduction in underground based carbon resources. According to an estimate, the reserves will last 218 yrs for coal, 41 yrs for oil and 63 yrs for natural gas. Depleting reserves of crude petroleum, uncertainty in availability, environmental degradation and rapid hike in petroleum prices have led to search of alternate fuels (Lin et al., 2011). Many researchers around the world have explored several alternative energy resources, like biogas, biomass, alcohol, hydrogen, vegetable oil, which have the potential to quench the ever-increasing energy thirst of today's population (Denis et al., 2009).

Biodiesel is a clean renewable fuel, which can be used in any CI engine without any modification. The feed stocks used for producing biodiesel are mainly high quality food grade vegetable oils, such as soya bean oil in U.S.A, rapeseed oil in Europe, palm oil in Malaysia (Azam et al., 2005). Lower cost feed stocks, such as waste cooking oil, grease, soap stocks are preferred because of their economic viability, since feedstock costs are about more than 85% of the total cost of biodiesel production (Hass et al., 2006; Zhang et al., 2003).Some of the properties, such as the high cetane value or good lubricity and lower sulphur content, are obvious advantages of bio-diesel while others, including the lower heating value, high freezing point (and inferior flow properties at low temperature), or corrosion properties are its drawbacks.

In this work, biodiesel was prepared from waste cooking oil and its production cost was calculated and compared with the cost of the petro-diesel.

MATERIAL

Many vegetable oils like Soybean, Groundnut, Rapeseed, Palm, Olive etc. are wildly used for frying. But after heating above a critical temperature for deep frying, they become unfit for further cooking, as their further use may lead to cholesterol formation in human beings. Thus WCO favourable feedstock for making biodiesel, as it is available in vast quantities and its safe is a challenge. (Buasri et al., 2008; Cigizoglu et al., 1997; Kerschbaum and rinke, 2004). Some researchers (Pugazhvadivu and Jeyachandran, 2005) suggested to pre-heating the WCO before using it in diesel engines which reduces the viscosity of the WCO and lowers the exhaust emissions as compared to the diesel.

WCO BIODIESEL PREPARATION

In this work the WCO is heated up to 120^{0}C for about 10 minutes in order to remove water content in the oil to avoid soap formation. This oil is then allowed to cool up to 65^{0}C temperature before mixing with KOH and methanol to prevent methanol evaporation. Simultaneously methyl alcohol (CH_3OH) is taken in molar ratio of 1:6 and Catalyst (KOH) is taken as 1% by weight of oil. Mixture of methyl alcohol and KOH is stirred until whole KOH dissolves in methyl alcohol. This mixture is poured in WCO. The mixture is stirred continuously for about 30 minutes and temperature of mixture is maintened at about 50-60^{0}C. The mixture is left for 2-3 hours for gravity separation of methyl esters and glycerol. The heavier glycerin settled at the bottom was removed and then remaining sample was washed in warm water (about 80^{0}C) by stirring with about 30% warm water for one minute and then, this water is allowed to settle to remove the catalyst and other impurities which are dissolved in water. Finally, the remaining sample is heated up to 110^{0}C ~120^{0}C for 8-10 minutes for removing any water content.

ECONOMICS OF BIO-DIESEL

The term "Life Cycle Assessment" is used to assess the total environmental performance of a product all along its lifetime, often referred as from 'cradle to grave'. Other terms, such as life cycle analysis and eco-balance, are also used. When talking about fuels, the proper term in use is "Well-to-Wheel Analysis (WTW)". This analysis is often divided into following five stages:

- Feedstock production.
- Feedstock transportation.
- Fuel production.
- Fuel distribution.
- Vehicle use.

COST ESTIMATION OF BIODIESEL PRODUCTION

Cost of Waste Cooking Oil

Assuming the market Price of WCO = Approx. 20 / Kg
Assuming a 800 Kg/day plant operation,
Requirement of WCO for a month of 25 days = 800 * 25 = 20000 Kg
Cost of WCO for a month = Rs. 20 * 25 * 800 = 400,000 Rs

Cost of Methanol

Assuming Price of Methanol Rs. 40/kg,daily requirement of Methanol = 176 Kg
Cost of Methanol for a month = 176 * 25 * 40 = 176,000 Rs
Cost of KOH
Price of 1Kg of KOH = Rs. 300 / Kg, daily requirement of KOH = 8 Kg
Cost of KOH for a month = 8 * 25 * 300 = 60,000 Rs

Cost of Water

Monthly requirement of water for water washing = 0.3 * 20000 = 6000 Kg
Cost of water for a month = 6000 * 0.25 = 1500 Rs
Total raw material cost for a month = 637,500 Rs
ELECTRICITY COST

Assumptions:

- 1KWh of electricity = Rs. 7/-(for industrial uses)
- Specific heat of WCO is 1.97 kJ/Kg
- Specific heat of water is 4.2 kJ/Kg
- Heat loss due to radiation, convection = 10%
- Power of heater is 40 kW.

1) Electricity cost for heating oil from 20 °C to about 120 °C.

$Q = m*C_p*\Delta T$ / efficiency
= 100 kg * 1.97 * (120-20) / 0.9 = 21888.89 KJ
Heating duration = 21888.89 / 40 = 547.22 sec or ~10 min is required to reach 120 °C.

Electricity cost = 1/6 h* 40 KW * 7
= 46.67 Rs / batch of 100 Kg oil
= 46.67 * 8 * 25 per month = 9334 Rs / month

2) Electricity cost for stirring alcohol and catalyst
Assumptions

- Power of motor is 7.2 kW assume to stir the solution for 10 minutes in 7 batches of 25 Kg each

Electricity cost per batch = 7.2 kW * 1/6 hr * 7 = 8.4 Rs
Electricity cost per month = 8.4 * 7 * 25 = 1470 Rs

3) Electricity cost for stirring alcohol and catalyst mixture with WCO for 30 minutes
Assumption

- Power of motor is 10 kW assume to stir the solutionfor 30 minutes Electricity cost per batch of (100+22+1=123) kg of mixture

= 10 kW * ½ hr * 7 = 35Rs
Electricity cost per month = 35 * 8 * 25= 7000 Rs

4) Maintenance of temperature during mechanical stirring
Tank in which mechanical stirring is taking place is insulated but still radiation losses takes place and even convection losses cannot be neglected. Cost of maintaining temperature of about 60 °C is assumed to be 900Rs per month.

5) Electricity cost for heating water 200C to 800C for water washing
Q (for 30 kg batch) $= m*C_p*\Delta T$ / efficiency
= 30 * 4.2 * 60 / 0.9 = 8400 kJ
Power of heater is 10 kW assume to Heat the solution for
= 8400 /10 =840 sec or 0.233 hr

Electricity Cost per batch = Rs. 0.233 * 10 * 7 = Rs. 16.33
Electricity Cost per month = 16.33 * 8 *25 = 3267 Rs

6) Electricity cost for final heating of sample to 120°C for removing water if present
Assume this cost to be 9000 Rs.
Total electricity cost involved is
= Rs. (9334 + 1470 + 7000 + 900 + 3267 + 9000) = Rs. 30,971

APPARATUS COST
Total cost of apparatus and equipments is about 200000 Rs. Assuming these equipments works for 10 yrs and taking 6% interest rate, Equipment cost for a month Rs. 2670 (approx.)

MISCELLANEOUS COST
Miscellaneous cost is as shown in Table 1.

Table 1

Purpose	Cost per month (Rs.)
Transportation Cost	8,000
Labour Cost	20,000
Rent Cost	2,000
Maintenance Cost	1,000
Manufacturing Unit Establishment Cost	2,500

Net Miscellaneous Cost = Rs. 33,500 for a month.

RECOVERABLE COST

- Generally methanol is used in the ratio of 6:1. Assuming 3.75:1 as the consumed ratio of alcohol.
- So, in a reaction 37.5% (1650 Kg) methanol is recovered
- Therefore, net recoverable cost of methanol = 1650 * 40 = Rs. 66000/ month.
- Glycerol obtained after completion of reaction is about 10% of oil (20,000Kg), and cost of 1Kg of glycerol is Rs. 40.
- Therefore, net cost of glycerol = 2,000 * 40 = Rs. 80,000 / month.

Table 1Total Production Cost of Bio-Diesel

S. No.	Purpose of Expenses	Total Cost per Month (Rs.)
1.	Raw material cost	637,500
2.	Electricity Cost	30,971
3.	Apparatus & Equipment Cost	2670
4.	Miscellaneous Cost	33,500
5.	Recoverable Cost	144,000
	Total Cost	Rs. 560,641/-

Cost of Bio-Diesel for One Unit
For 90% yield of biodiesel from the waste cooking oil.
Cost of Biodiesel for 1Kg. = Rs. 560,641 / 18,000 Kg = Rs. 31.14
Net Bio-Diesel Cost = Rs. 31.14/Kg.
Cost of Waste Cooking Oil = Rs. 20/Kg.
Therefore net processing Cost = Rs. 11.14/Kg.
Assume 15% distribution cost, dealer commission etc.
Total Cost of Bio-Diesel of 1Kg. = Rs. 35.82/-

CONCLUSION
On the basis of present work it can be concluded that the biodiesel conversion cost comes about 11 rupees per kg, hence with waste cooking oil net biodiesel cost comes at 35 rupees per kg where as diesel cost without subsidies. Hence waste cooking oil biodiesel found to be a better alternative to petro diesel and in future help to acquire the energy security for coming generations and provide a safe passage for waste cooking oil disposal.

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